NRC Public Meeting to Discuss Industry Sump Evaluation Methodology

Tuesday, March 23, 2004

Opening Remarks, Introductions and Meeting Objectives	9:00-9:15	NEI/NRC
Industry Evaluation Guidance o Process Overview o Baseline Analysis • Local Debris Generation • Global Debris Generation • Size Distribution • Transport • Headloss	9:15-12:00	Industry
Lunch Break	12:00-1:30	
Industry Evaluation Guidance (continued)	1:30-2:00	Industry
Risk-Informed Treatment of Sump Performance o Use of Alternate Break Size in DB Analysis • Alternate Break Size, Configuration and Location o Demonstration of Mitigation Capability • Use of “realistic” assumptions • Credit for non-safety equipment/actions • Success Criteria o Process for Implementation • Exemption Template • Exemption Requests o Schedule and Actions	2:00-3:30	All
Discussion/Opportunity for Stakeholder Input	3:30-4:00	All

Wednesday, March 24, 2004

Introductions	9:00-9:10	
Industry Evaluation Guidance (continued) o Supplemental Guidance • Local Debris Generation • Transport o RAI Responses o Schedule and Actions	9:10-11:30	Industry
Discussion	11:30-12:00	All

GSI-191 Evaluation Methodology Overview

March 23, 2004

GSI-191 Evaluation Methodology

- Evaluation Methodology structure and content have been revised from October draft
- Changes are responsive to NRC and Industry comments
  - NRC preliminary review documented in 2/9/2004 letter
  - NRC response to industry debris generation proposals provided in 3/4/2004 letter
  - Detailed set of RAIs provided on 3/10/2004

Baseline Analysis

- Approach now uses a "Baseline" analysis approach
  - Used as a first step in evaluation methodology
  - Provides a simplified set of analysis guidelines
  - A high level of conservatism is maintained at each step of the analysis
  - Intended to guide licensee decision process

Baseline Analysis

- Common baseline analysis approach expected to facilitate NRC review and closeout of licensee responses to expected generic letter
- Baseline analysis would be performed by each PWR licensee using current or proposed containment/sump configuration

Baseline Refinement

- Upon completion of baseline analysis, the results will indicate either adequate NPSH margin or a need to refine the analysis
- Analysis refinement will be accomplished through a combination of:
  - Input/Design Revision
  - Method Revision
- Guidance will identify appropriate refinements to be considered

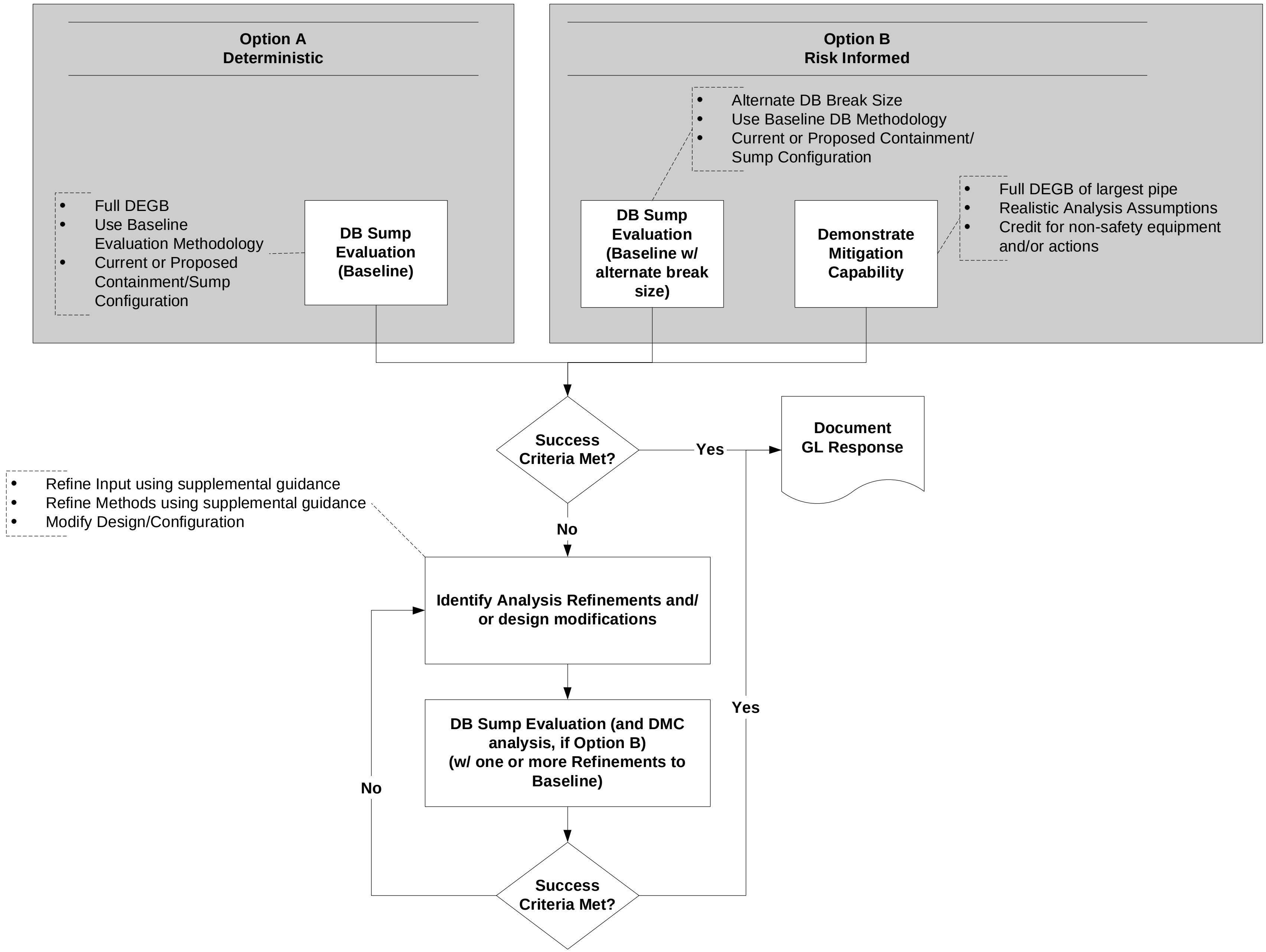
Baseline Refinement Methods

- Decision on method(s) of Baseline refinement will likely be driven by plant specific needs (e.g., plant design, economics, schedule)
  - **Input/Design Revision**: Could reflect changes to plant design or operation (Example: modification of debris source term to reflect insulation changeout or modifications to screen design)
  - **Method Revision**: Enable plant specific features to be treated explicitly; remove excess conservatism inherent in baseline approach (Example: More detailed analysis or transport using CFD analysis; use of insulation specific destruction pressure)
- Refinements of input/methods/design performed as necessary to meet all appropriate success criteria

Deterministic vs. Risk-Informed Baseline

- Potential for “risk-informed” GSI-191 resolution identified in March 4, 2004 NRC letter
- Process flowchart reflects deterministic approach (Option A) and risk-informed approach (Option B)
- Evaluation Methodology easily accommodates either “deterministic” or “risk-informed” process
  - Design Basis analysis would generally be the same (Baseline methods and refinements would apply to both processes)
  - Differences between “deterministic” and “risk-informed” design basis analysis expected to be confined to definition and treatment of postulated break size
- Additional analyses would be necessary for Option B approach

PWR Containment Recirculation Sump Performance Evaluation Process Overview



March 15, 2003

Overview of the Baseline Document

Mo Dingler
Wolf Creek Nuclear Operating Company

Baseline Document

- Objective:
  - Provide a single suggested approach for utilities to perform a baseline evaluation of their PWR containment sump
    - Provide a common approach for the initial evaluation
    - If a plant evaluation shows sufficient margin for head loss
      - NO additional evaluation is required for determining sump capability.
    - Provide a conservative approach for all plants
    - Some plants will have to use the Supplemental Guidance to "pass"
    - Will allow plants to determine how to move forward based on evaluation result
    - Will allow plants to do "what if" cases

Baseline Document

- Baseline Document
  - Addresses Three Areas Identified as Governing Post Accident Sump Performance
    - Debris Generation
    - Debris Transport
    - Head Loss
  - Provides a Sample Calculation In Each Topic Area
- Ongoing research activity
  - Chemical effects- to be address later as appropriate
- Topics outside scope of Baseline Document
  - Downstream Effects
  - Structural Analysis of the Sump Screens

Baseline Document

- Debris Generation
  - Break Size
    - Provides a Outline on How to Select the “Worst” Location
  - ZOI
    - Provides Tables Based on Different Insulation Types
  - Sample Calculation Assumptions
    - 10 inch Break at a Selected Location
    - ZOI Sphere Radius of 12 Times the Break Diameter

Baseline Document

- Debris Transport
  - Use of Logic Trees for Transport and Retention
  - Logic Trees incorporate a simplified, conservative flow model
    - Identify what Insulation is Retained and Where
    - Identify What Insulation is Transported to the Sump
  - Three Logic Tree Types
    - Highly Compartmentalized
    - Mostly un-compartmentalized
    - Ice Condensers
  - Sample Calculation
    - Carries Forward from the Debris Generation Section

Baseline Document

- Head Loss
  - Uses NUREG –6224 or design specific screen correlation as appropriate
  - Evaluates Thin Bed Head Loss
  - Evaluates Head Loss with Debris Loading Beyond the Thin Bed
  - Sample Calculation
    - Carries Forward the Debris Transport Section

PWR Containment Sump Baseline Evaluation Methodology

Break Selection

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March 24, 2004

BREAK SELECTION

- First step in assessing post-accident sump screen performance
  - Size of the break, and,
  - Location of the break.
- Objective
  - Determine the break location that provides for debris generation that is evaluated to provide for the maximum head loss across the sump screen

Postulated Break Size

- **Double-Ended Guillotine Break**
  - A double-ended guillotine break (DEGB) of piping, including the primary system piping
  - NRC accepted this approach in resolution of BWR ECCS strainer blockage concerns
  - This method is applicable to all PWR designs
- **Alternate Break Size**
  - Based on a risk-informed considerations
  - Less than the DEGB

Identifying Break Locations

General Guidance

- Break exclusion zones not considered
- NRC Branch Technical Position MEB 3-1 not used
- Pipe breaks postulated such that each location results in a unique debris source term
- Breaks postulated in locations containing high concentrations of problematic insulation
- Pipe breaks shall be postulated with the goal of creating
  - Largest quantity of debris and or
  - Worst-case combination of debris types.
- Piping attached to the RCS that is small (< 2 inches in diameter) need not be considered

Piping Runs to Consider

- Hot leg, cold leg, intermediate (crossover) leg and surge line
- Piping attached to the reactor coolant system. Examples include, but are not limited to Charging Lines and/or RHR lines.
- Some plant designs require plants to eventually recirculate coolant from the sump for pipe ruptures other than a LOCA
  - Main feedwater breaks
  - Steam line breaks

Other Considerations

- Identify break locations that result in the most direct flow path to the containment sump.
- Identify locations that result in the generation of two or more different types of debris.
- If insulation does not result in the generation of significant particulate debris, attention should be given to the characterization of latent debris sources

Initial Break Location

- Examine multiple locations
- Suggested the initial break location is the junction of the primary piping and the steam generator (LOCA)
  - Will result in a large amount of debris
  - Steam generators often have multiple insulation types
  - The location is a convenient place to start

Break Intervals

- Purpose is to determine the limiting break location
- For primary piping (LOCA)
  - Use 3-foot increments along the pipe
  - This provides for an acceptable determination of the limiting break location with respect to both:
    - The maximum volume of debris that may be generated and transported to the sump screen, and,
    - The worst combination of debris that may be generated and transported to the sump screen.
- For main steamline and feedwater breaks, review current licensing basis for break locations and characteristics to determine postulated ZOI
- For attached piping, only the length of pipe run up to the isolation point need be considered

Sample Calculation

- A 10-inch break will be used
- A single location is selected for the sample
  - At the base of the steam generator
  - Provides for multiple debris types

PWR Containment Sump Baseline Evaluation Methodology

Debris Generation

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March 24, 2004

Introduction

- Following break selection, determine an appropriate the zone of influence (ZOI) within which debris is generated
- Not all debris generated is transported to the sump.
- Thus, debris generation is a two-step process:
  - First, evaluate an appropriate ZOI in which debris is generated.
  - Second, evaluate the characteristics of the debris generated
- The identification of the ZOI and resulting debris characteristics is presented here

Zone of Influence

- The ZOI is defined as the volume about the break in which the fluid escaping from the break has sufficient energy to generate debris from insulation, coatings, and other materials
- For the baseline calculation, it is recommended that the boundary of the ZOI be assumed to be spherical, with the center of the sphere located at the break site
  – The use of a spherical ZOI is intended to encompass the effects of chaotic jet expansion resulting from impingement on structures and components

Recommended ZOI Size

- ANSI/ANS 58.2-1988 standard used
  - Appendices B, C, and D of the standard provide the guidance necessary to determine the geometry of a freely-expanding jet
  - Guidance is provided for jets originating from a variety of reservoir conditions, including subcooled conditions
  - Used to determine the geometry of a jet originating from a postulated break in a PWR piping system
  - Subcooled reservoir and flashing break flow were assumed for the calculations

ZOI Calculation

- Mass flux determined using Henry-Fauske model for subcooled water blowdown through nozzles based on a homogeneous non-equilibrium flow process. No irreversible losses were considered.
- The initial and steady-state thrust forces were calculated based on the guidance in ANSI/ANS 58.2-1988
- The jet outer boundary and regions mapped for a circumferential break with full separation
- A spectrum of isobars was mapped
- The volume encompassed by the various isobars was calculated
- Radius of an equivalent sphere calculated to encompass the same volume as twice the volume of a fee jet for a given isobar
- This radius is taken to be the radius of the ZOI

ZOI Conditions

- A circular break geometry
  - Representative of both a postulated DEGB of primary piping as well as the DEBG of piping attached to the RCS
  - Provides for a maximum debris generation volume as there are two ends of the break to release fluid
- Fluid reservoir conditions of 2250 psia and 550 ˚F
- Ambient pressure of 14.7 psia
  - Conservative, no credit is taken for containment backpressure
- The ZOI is expressed as the ratio of the radius of the equivalent ZOI sphere to break size diameter.
  - Allows the ZOI to be expressed independent of the break size

ZOI Summary

Insulation Types	Destruction Pressure (psi)	ZOI Radius (Radius/Break Diameter)	
		Calculated Value	Recommended Value
RMI	190	1.25	1.3
Cal-Sil (Al. cladding, SS bands, seam @ 180°)	64	2.85	2.9
Cal-Sil (Al. cladding, SS bands, seam @ 0°)	50	3.22	3.3
Cal-Sil (Al. cladding, SS bands, seam @ 45°)	24	3.54	3.6
Unjacketed Temp-Mat Fiberglass	17	7.6	7.7
Unjacketed, Jacketed NUKON	10	11.9	12.0
Min-K, Koolphen	4	21.4	21.5

Selecting A ZOI

- ZOI selected based on minimum destruction pressure of insulation inside containment
  - This ZOI is then applied to all insulation types
  - Provides for the calculation of a conservatively large debris generation
- For robust barriers such as walls and components, re-define the outer boundary of the ZOI
  - No debris production beyond robust barriers
  - The volume encompassed by the ZOI is preserved

Adjusting ZOI for Barriers

- Determine the volume of the sphere that extends beyond the robust barriers
- Increase the volume of the ZOI in the unconstrained regions of containment, determine additional regions of containment that would be encompassed by the ZOI after the border is re-defined
- Calculate the actual volumes that would be encompassed by the ZOI.
- Repeat calculations until ZOI boundary defined
- For cases in which the ZOI would nearly encompass an entire compartment, take the ZOI to encompass the entire compartment
- Once the boundary of the ZOI has been defined, proceed with determining the amount of debris that is generated within the ZOI.

Debris Generation Within ZOI

- Calculate the debris generated within the ZOI
  - Information about the type, location and amount of debris sources within the containment are obtained from plant drawings and the results of a condition assessment walk-down such as described in NEI 02-01
  - The characterization of the debris (transport characteristics) is evaluated using information included in the Baseline Guidance

Sample Calculations

- Assume a 10-inch break of piping attached to the RCS
- Walk-down data for the plant is available
- The break is assumed to be at the steam generator
  - Both RMI and Nukon are installed on the steam generator.
- From the ZOI table
  - The ratio of ZOI radius to break diameter is 12
  - The radius of the ZOI is 10 feet
  - Applied to all insulations types in the region within the ZOI.
- From containment drawings and walk-down data, a ZOI with a radius of 10 ft generates:
  - 15,000 ft^2 of RMI
  - 300 ft^3 of Nukon insulation

PWR Containment Sump
Baseline Evaluation Methodology

Latent Debris

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March 24, 2004

Definition

- Defined as dirt, dust, paint chips, fibers, pieces of paper (shredded or intact), plastic, tape, or adhesive labels, and fines or shards of thermal insulation, fireproof barrier, or other materials in containment prior to the break
- Dust and dirt includes miscellaneous particulates present in the containment
- Potential origins include activities performed during outages and foreign particulates brought into containment during outages

Background

- Due to the variations in containment design and size from unit to unit, many miscellaneous sources should be evaluated
- FME programs cannot entirely eliminate sources of miscellaneous debris unless verified by plant-specific walkdowns
- Plant-specific walkdown results can be used to determine a conservative amount of dust and dirt to be included in the debris source term.
  - Will not be able to directly measure this type of debris
  - However, it is possible to quantify the amount of debris with additional steps.

Approach

- Calculate horizontal surface area inside containment
  - Latent debris is typically small and settles on horizontal surfaces.
  - Calculation determines total area for debris accumulation
- Evaluate the resident debris buildup
  - Necessary to determine the amount of debris on surfaces inside containment
- Define the debris characteristics
  - Used in subsequent steps of the sump performance evaluation
- Calculate the total quantity and composition of debris
  - Also used in subsequent steps of sump performance evaluation

Calculate Horizontal Surface Area

- Surfaces include floor area, cable trays, equipment (such as valve operators, etc.), and other surfaces, as appropriate (junction boxes, etc.)
- Area projected onto the horizontal plane by the surface determines settling and accumulation of debris
- Simplify surface area calculations
- Use half of the surface area of round surfaces
- Perform thorough calculations to determine the surface area to be considered for each area of containment
- Use estimated dimensions if exact dimensions unavailable

Evaluate Resident Debris Buildup

- Recommend a survey of containment be performed
  - Surveying containment ensures that higher-than-average debris loads are accounted
  - Allow credit for smaller latent debris loading
- If licensee has rigorous programs in place to control the cleanliness of containment and documents the condition of containment following an outage, it is adequate to perform inspections and limited sampling of surfaces
- If not, it is necessary to perform more comprehensive surveys.

Evaluate Miscellaneous Debris

- Account for other miscellaneous debris sources
  - Equipment tags: Determine the number and location of equipment tags of each material type (paper, plastic, metal) within containment.
  - Tape: Determine the amount and location of each type of tape within containment.
  - Stickers or placards affixed by adhesives: Include items such as stickers and signs that are not mechanically attached to a structure or component in the latent debris source term

Define Debris Characteristics

- Use two methods:
  - Analyze debris samples to determine composition and physical properties.
  - Assume composition and physical properties of the debris, using conservative values.
- Recommended debris characteristics:
  - A fiber/particulate mix that results in a thin bed
  - Fiber Density = 62.4 lbm/ft^3
  - Particle Density = 100 lbm/ft^3
  - Particle Diameter = 10 μm
- Ongoing research efforts may provide additional information on latent debris physical characteristics

Determine Debris Surfaces

- Not all horizontal areas susceptible to accumulation of debris
  - Housekeeping activities involve cleaning floors with special wipes, vacuum cleaners, or other methods
- Determine the fraction of the surface area of each component and surface that is susceptible to debris accumulation
- Assume 100% of inaccessible horizontal surface area is susceptible to debris accumulation
- Evaluate the fractional area susceptible to debris accumulation

Calculate Debris

- Compute the total quantity of latent debris using the surface areas and debris characteristics as inputs
  - The calculations performed on an area-by-area basis
  - Compute total quantity of debris for each area by multiplying the total surface area susceptible to debris accumulation by the debris layer thickness for the area of containment being considered.
  - Include quantities of other types of latent debris such as tape, equipment tags, and stickers.
- Categorize and catalog the results for input to the debris transport analysis

Sample Calculation

	Description	Length	Width	Surface Area	Layer Thickness	Density	Debris Volume	Multiplier	Debris Mass
		ft	ft	ft^2	in	lbm/ft^3	ft^3	--	lbm
Floor Areas									
1	Area between SG rooms and cont. shell			6914.0	0.001	100.0	0.58	1	57.62
2	SG rooms (4 rooms)			1864.0	0.001	100.0	0.16	1	15.53
3	RCDT room	24.00	8.00	192.0	0.001	100.0	0.02	1	1.60
4	RCDT HX room	20.00	6.75	135.0	0.001	100.0	0.01	1	1.13
5	RCDT HX room anteroom	13.30	11.25	149.6	0.001	100.0	0.01	1	1.25
6	Excess letdown HX rm	22.25	4.25	94.6	0.001	100.0	0.01	1	0.79
7	Seal table room			379.8	0.001	100.0	0.03	1	3.17
Equipment									
1	Sump drain pump cover	6.00	4.00	24.0	0.001	100.0	0.00	1	0.20
2	Cable trays	300.00	1.00	300.0	0.001	100.0	0.01	1	1.25
Grand Total								***Grand Total***	82.52
	Notes:								
	Sump top plate surface area included in Floor Area #1								
	Calculations for floor areas #1, 2, 7 documented separately								
	One half of surface area considered for areas where debris thickness is used.								
	Debris layer thicknesses are hypothetical, not based on actual survey data.								

Debris Characteristics

- Debris characteristics are:
  - the post-LOCA size distribution of a material, and
  - the debris material size and shape as well as the micro-density (i.e. material density) and macro-density (i.e. as fabricated density)
- The debris generation section provides the following items as inputs:
  - The volume of insulation material in a ZOI
  - The surface area of the ZOI for coatings
  - The total quantity of indeterminate and unqualified coating inside containment.
  - The total quantities of indeterminate and unqualified coating that have been applied to piping and equipment that are covered by undamaged insulation.

Post-DBA Debris Size Distribution

– Debris from the ZOI

  Debris generated by the postulated pipe break

– Debris from outside the ZOI

  Debris generated by the post-DBA environment

    Containment spray

    Immersion in the Post-DBA containment pool

Debris from the ZOI

- The AJIT indicated a dependence of the size distribution of the debris as a function of distance from the nozzle
- Section 3.3 of NUREG/CR-6808 suggests a method to correlate size distribution to the ZOI
- Very little size distribution data for materials other than NUKON®

Debris Size Classification

- Previous debris size classification schemes:
  - –NUREG/CR-6369: 5 fibrous classification schemes with 3 to 7 fiber size/categories
  - –NUREG/CR-6224: 7 size/categories
  - –Numerous other classification schemes
- Baseline Guideline classification scheme
  - –Small Fines: debris < 4 inches
  - –Large Pieces: debris > 4 inches

Size classification based on the generally encountered largest openings of gratings, radiological protection fences, and trash racks: 4 inches

Debris Size Classification (cont.)

- Small Fines:
  - All material that can pass through an opening of 4 inches or more
  - Small Fines size debris becomes elemental size of the material e.g. fibers for fibrous blankets and particles for coatings
  - Erosion and disintegration implicitly accounted for in the small fines category

Debris Size Classification (cont.)

- Large Pieces:
  - All material that <u>cannot</u> pass through an opening of 4 inches or more
  - Large Pieces of insulation material assumed to be jacketed

    No erosion or disintegration of Large Pieces since they are jacketed (NUREG/CR-6369)

  - Large Pieces do not transport

Debris Size Classification – Fibrous Material in ZOI

- NUKON® blankets - AJIT test that generated the largest amount of non-large pieces (small fines):
  - 60 % of fibrous insulation in ZOI become small fines (individual fibers)
  - Conservative estimate based on the single OPG fibrous test (2 phase): 48% large pieces
- Use NUKON® blankets for all fibrous material tested at in the AJIT that had the same or higher destruction pressure
  - A higher destruction pressure indicates a more robust material less likely to produce more fines than a more fragile material.
- Use 100% small fines for all fibrous material that had a destruction pressure less than NUKON® or was not tested at AJIT.
  - *Small fines transport*
  - *Large pieces (assumed to be jacketed) do not transport or erode*

Debris Size Classification – RMI in ZOI

- Use size distribution of NRC Karlstein Test of Diamond Power RMI for all RMI:
  - Conservative estimate: all other RMI cassettes tested at AJIT had a significantly higher destruction pressure than Diamond Power RMI and the size distribution was mostly very large pieces
- Use Figure 3-7 of NUREG/CR-6808:
  - Small RMI pieces: 75%
  - Large RMI pieces: 25%

Small RMI pieces transport

Large RMI pieces do not transport

Debris Size Classification
Other Material in the ZOI

- Cal-Sil: 100% as small fines
  - Assumes all Cal-Sil to be soluble
- Min-K, Microtherm, Koolphen, all types of Fire barriers, Lead Wool, Generic Fiberglass, Generic Mineral Wool: 100% as small fines
- Coatings: 100% as small fines - “Inorganic Zinc” – (IOZ) equivalent

Debris Size Classification
Material Outside the ZOI

- All intact jacketed insulation does not generate debris by post-DBA conditions – NUREG/CR-6369 & SER on NUKON blankets
- Other Material:
  - Fire barrier: 100 % erosion to small fines
  - Lead Blankets: no debris generated from intact lead blankets.
  - Coatings:
    - All types of DBA qualified: no debris
    - All types of Indeterminate and DBA-unqualified / unacceptable: 100% as small fines ("IOZ" equivalent)
  - Latent Debris: reference appropriate section

Debris Size Classification Results

- From debris generation section:
  - NUKON in ZOI: 300 cu ft
  - RMI in ZOI: 15,000 sq ft
  - Radius of coating ZOI: 10 ft

Debris Size Classification Results (cont.)

- NUKON:
  - Quantity of small fines of NUKON® in the ZOI: 300 cu ft * 60% = 180 cu ft
  - Quantity of large pieces of NUKON® in the ZOI: 300 cu ft * 40% = 120 cu ft
- RMI:
  - Quantity of small fines of RMI in the ZOI: 15,000 sq ft * 75% = 11,250 sq ft
  - Quantity of large pieces of RMI in the ZOI: 15,000 sq ft * 25% = 3,750 sq ft

Debris Size Classification Results (cont.)

- Coatings:
  - From ZOI:
    - The surface area of a 10 ft sphere is 1256.6 sq ft.
    - Failed coatings from the ZOI: 1256.6 sq ft * 7.5 E-4 ft =

    0.94 cu ft of IOZ equivalent debris (6 mils epoxy + 3 mils IOZ)

  - Outside ZOI:
    - From the plant Appendix R: 190,000 sq ft of coatings.
    - From the plant construction records : 160,000 sq ft to be DBA qualified.
    - DBA-unqualified / unacceptable and indeterminate coatings 30,000 sq ft. None of these coatings are covered.
    - Coating from outside ZOI: (30,000 sq ft - 0 sq ft of covered by undamaged insulation.) * 2.5E-4 =

    7.5 cu ft of IOZ equivalent debris (3 mils IOZ equivalent)

Debris Transport

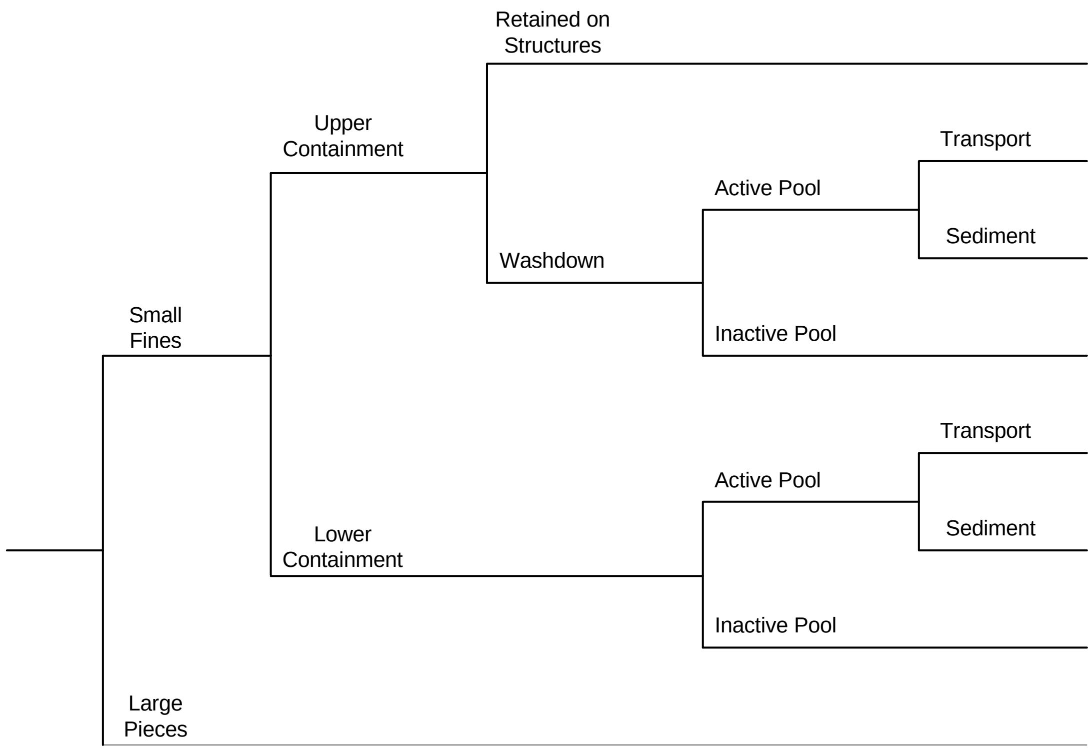
- Use of Logic Trees for transport
  - Identifies the fraction of debris that is transported to the sump
- Three logic tree types
  - Highly Compartmentalized
  - Mostly Un-Compartmentalized
  - Ice Condensers
- Calculation
  - Carries forward the debris quantities calculated in the debris generation and debris characterization sections

Debris Transport Logic Trees

- Introduced in NUREG/CR-6369 for BWRs and used in the NUREG/CR-6762 series of GSI-191 studies for PWRs
- Baseline Guidance adopts 4 phases of debris transport:
  - Blowdown
  - Washdown
  - Pool Formation
  - Recirculation

Un-quantified Logic Tree

Debris Size	Blowdown Transport	Washdown Transport	Pool Fill Transport	Recirculation Transport



Generic Types of Containment

- Highly Compartmentalized
  - have distinct robust structures/compartments totally surrounding the major components of the RCS
- Mostly Un-Compartmentalized
  - have partial robust structures surrounding the steam generators
- Ice Condensers
  - open lower containment

Inactive / Active Sumps

- Inactive (dead end) sumps
  - Below the containment floor elevation
  - Does not participate in recirculation flow
    - ✓ No drains from upper containment
- Active sump
  - Containment floor

Debris will preferentially be transported to the inactive sumps during pool formation by the fast initial sheeting flow hence assuming that all transportable debris is homogeneously distributed in all the water volume in containment is conservative.

Transport Simplifications

- Blowdown
  - Small fines can be transported throughout containment
    - Highly compartmentalized & Ice condenser

  - Large pieces transported to the containment floor

Transport Simplifications (cont.)

- Washdown
  – Small fines/pieces transported to upper containment can be transported back to containment floor

  – Large pieces not transported on the containment floor

Transport Simplifications (cont.)

- Pool formation
  - Fraction of small fines/pieces on the containment floor transported to inactive sumps

    Inactive sump transport fraction =

    Volume of Inactive sump / Total water volume

  - Large pieces not transported on the containment floor

Transport Simplifications (cont.)

- Recirculation
  - All small fines/pieces on the containment floor are transported to the sump
  - Large pieces not transported on the containment floor

Transport of Fibrous Debris From ZOI

- Blowdown
  - Small fines transport to upper containment
    - 25% highly compartmentalized
    - 0% mostly un-compartmentalized
    - 10% ice condenser
  - Large pieces: containment floor

Transport of Fibrous Debris From ZOI (cont.)

- Washdown
  - Small fines transport to containment floor
    - 100% highly compartmentalized
    - 0% mostly un-compartmentalized
    - 100% ice condenser
  - Large pieces: containment floor

Transport of Fibrous Debris From ZOI (cont.)

- Pool formation
  - Small fines: Fraction transported to inactive sump
  - Large pieces: Containment floor

Transport of Fibrous Debris From ZOI (cont.)

- Recirculation
  - Small fines: 100% transport to sump
  - Large pieces: 0% transport to sump

Transport of RMI Debris From ZOI

- Blowdown
  – Small pieces transport to upper containment
    - 25% highly compartmentalized
    - 0% mostly un-compartmentalized
    - 10% ice condenser
  – Large pieces: containment floor

Transport of RMI Debris From ZOI (cont.)

- Washdown
  - Small pieces transport to containment floor
    - 0% highly compartmentalized
    - 0% mostly un-compartmentalized
    - 0% ice condenser
  - Large pieces: containment floor

Transport of RMI Debris From ZOI (cont.)

- Pool formation
  - Small pieces: Fraction transported to inactive sump
  - Large pieces: Containment floor

Transport of RMI Debris From ZOI (cont.)

- Recirculation
  - Small pieces: 100% transport to sump
  - Large pieces: 0% transport to sump

Transport of Other Debris (cont.)

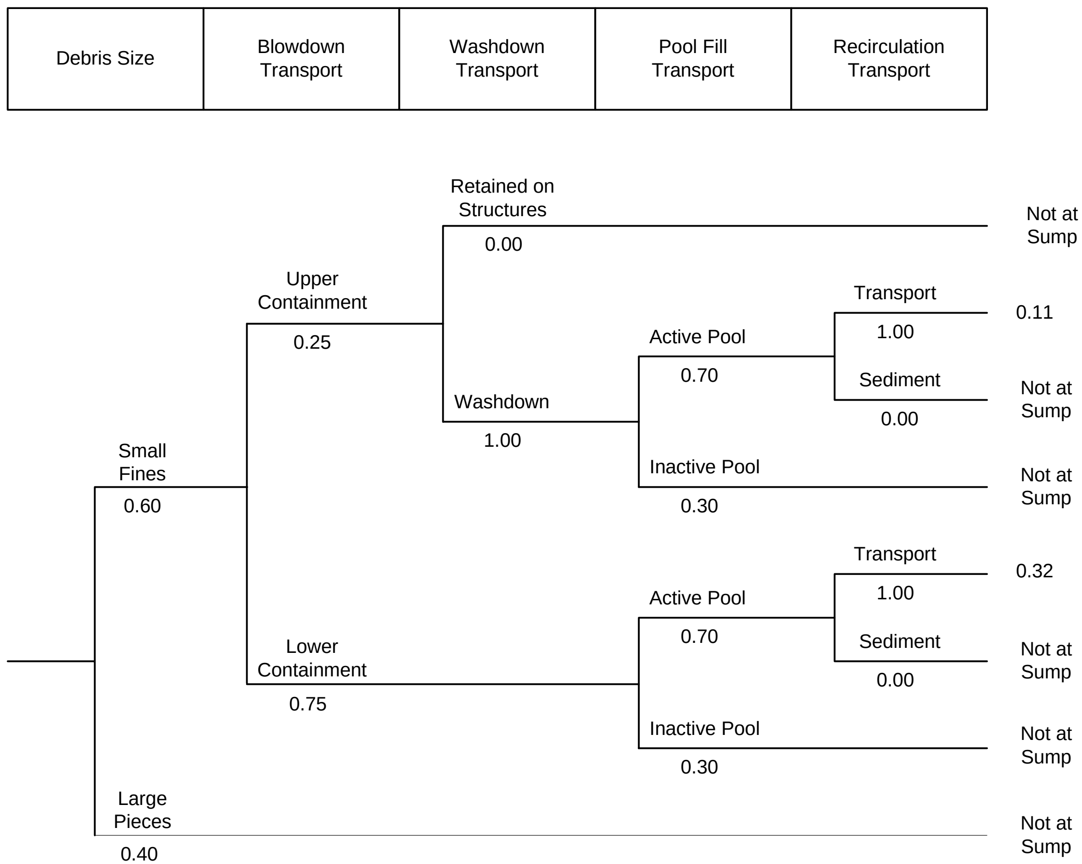
- From the ZOI
  - 100% transport to sump

- From Outside the ZOI
  - 100% transport to sump

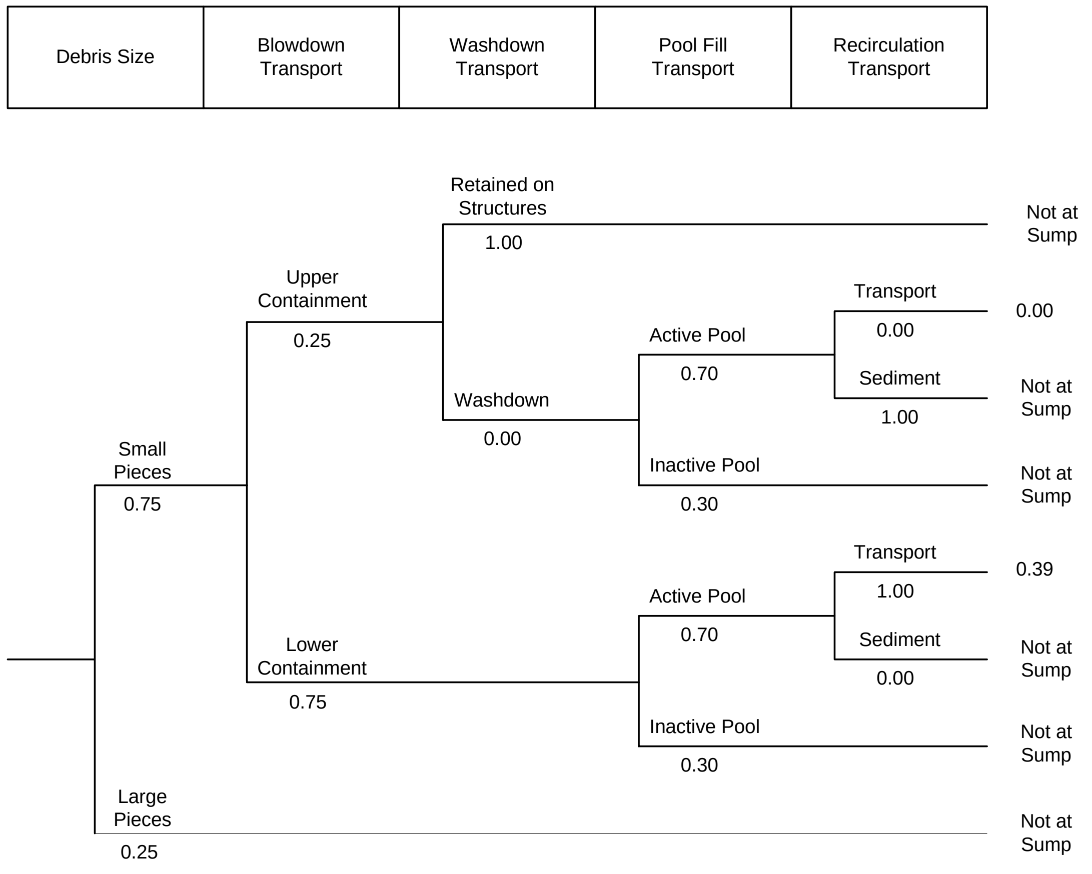
Sample Calculation

- From Debris Generation
  - Highly compartmentalized containment
  - NUKON
  - RMI
- From Water Level Calculation:
  - Inactive Sump Volume/Total post-DBA water volume in containment = 0.30

Sample Calculation: NUKON Logic Chart



Sample Calculation: RMI Logic Chart



Sample Calculation
Transport Factor Results

- NUKON: 43%
- RMI: 39%
- Coatings in ZOI: 100%
- Coatings Outside ZOI: 100%
- Latent Debris: 100%

Sample Calculation Results

- From debris generation section:
  - NUKON in ZOI: 300 cu ft
  - RMI in ZOI: 15,000 sq ft
- From the debris characterization section:
  - Coatings in ZOI: 0.94 cu ft
  - Coatings outside ZOI: 7.5 cu ft
- From latent debris section:
  - Latent fiber: 42.76 lbs @ 62.3 lbs/cu ft = 0.7 cu ft
  - Latent particulates: 42.76 lbs @ 100 lbs/cu ft = 0.4 cu ft

Sample Calculation Results (cont.)

- Fibers: small fines: 300 * 0.43 + 0.7 = 129.7 cu ft

- RMI small pieces: 15,000 * 0.39 = 5,850 sq ft

- Coating small fines (IOZ equivalent): 8.44 cu ft

- Latent Particulates: 0.4 cu ft

Head Loss

- Uses NUREG/CR-6224 head loss correlation
  - *Baseline also allows use of design specific correlation*

- Evaluates head loss with the calculated debris loading

- Evaluates Thin Bed head loss

- Calculation
  - Carries forward the debris quantities calculated to reach the sump by the debris transport section

Head Loss (Cont.)

- Inputs for Head Loss Calculations
  - Sump Screen Design
  - Thermal-Hydraulic Conditions
  - Debris Characteristics
- Head Loss Methodology
  - General Theoretical/Empirical Formulas
  - Methodology Application Considerations
  - Methodology Limitations
- Sample Calculation
  - Fiber + Particulate
  - RMI
  - Thin Bed

Inputs for Head Loss Calculations

- Sump Screen Design
  - Size (circumscribed area)
  - Submergence
- Thermal-Hydraulic Conditions
  - Recirculation Pool Water Level
  - ECCS Flow Rate
  - Temperature
  - Debris Types, Quantities and Characteristics

Head Loss Methodology

- General Theoretical/Empirical Formulas
- Methodology Application Considerations
- Methodology Limitations

Head Loss Methodology (cont.)

General Theoretical/Empirical Formulas

- Fibrous + Particulate: NUREG/CR 6224
- RMI: Appendix K of the NRC SER to the BWROG URG
- Fibrous + Particulate + RMI:
  (Fiber + Particulate) + RMI
- Cal-Sil
- Microporous

Head Loss Methodology (cont.)

Methodology Application Considerations

- Total Sump Screen Head Loss
- Evaluation of Breaks with Different Combinations of Debris
- Thin Fibrous Beds + Particulate
- Sump Screen Submergence

Head Loss Methodology (cont.)

Methodology Limitations

- Flat Screen Assumption
- Assumes Uniform Deposition on Sump Screen Surfaces
- Very Thin Fiber Beds

Head Loss Methodology (cont.)

Sample Calculation

- RMI
- Fiber + Particulate
- Thin Bed

Head Loss Methodology (cont.)

Sample Calculation

- Strainer area: 200 sq ft
- ECCS flow: 9,000 gpm (approach velocity: 0.1 ft/sec)
- Water temp: 200 F

Head Loss Methodology (cont.)

RMI

- From Debris Transport
  - RMI small pieces: 5,850 sq ft

Head Loss: 0.2 ft water

Head Loss Methodology (cont.)

Fiber + Particulate

- From Debris Transport
    - Fibers: small fines: 129.7 cu ft
    - Coating small fines (IOZ equivalent): 8.44 cu ft (~2,800 lbs)
    - Latent Particulates: 0.4 cu ft

Head Loss: 43 ft water (7.7” compressed to 3.2”)

Reduce the 30,000 sq ft of failed coating outside ZOI to 3,000 sq ft: 4.5 ft water

Reduce the 30,000 sq ft of failed coating outside ZOI to 0 sq ft: 3.6 ft water

Head Loss Methodology (cont.)

Fiber + Particulate

- Thin bed:
    - Fibers: small fines: 0.2 cu ft
    - Coating small fines (IOZ equivalent): 8.44 cu ft (~2,800 lbs)
    - Latent Particulates: 0.4 cu ft

Head Loss: NA ft water (outside bounds of correlation)

Reduce the 30,000 sq ft of failed coating outside ZOI to 3,000 sq ft: 8.5 ft water

Reduce the 30,000 sq ft of failed coating outside ZOI to 0 sq ft: 5.5 ft water

GSI-191 Evaluation Methodology Supplemental Guidance

March 24, 2004

NEI

Supplemental Guidance

- Includes all guidance outside of baseline analysis description
- Three known areas of supplemental information
  - Method Refinements
  - Design/Input Refinements
  - Closure Items

Supplemental Guidance

- Supplemental guidance will include specific guidance and “simple pointers” to refinements that will need to be supported by individual licensee

Method Refinements

- Areas where specific guidance will be provided:
  - **Break Location** – No additional specific guidance beyond baseline guidance guidance. "Pointer" will be provided on plant specific exclusion of piping in close proximity to sump screen
  - **ZOI** – Additional guidance will be provided to allow more precise determination of ZOI
  - **Latent Debris Characteristics** – no additional guidance beyond baseline is anticipated
  - **Latent Debris Quantity** – no additional guidance beyond baseline is anticipated
  - **Debris Characteristics** – no additional guidance beyond baseline is anticipated
  - **Debris Transport** – Guidance for more explicit treatment of transport will be provided (CFD and nodal) along with additional guidance on treatment of physical barriers
  - **Headloss** – Additional material data already provided in October draft will be added
  - **Thin Bed Effects** – Additional guidance to address less than 100% filtration efficiency for particulates will be added
  - **Operational/License Changes** – No know specific guidance but will include "pointers" to plant specific refinements such as refinement of NPSH methodology, limited credit for containment backpressure

Design Refinement

- Guidance will identify the full range of design changes that can be considered:
- Including:
  - Enlargement of passive screens
  - Active screens
  - Insulation change out
  - Barriers to debris transport

Closure Items

- Downstream effects – Guidance will address limiting flow clearances
- Structural capacity of screen
- Chemical precipitation